S-HIS Validation of AIRS and TES Radiances: AVE and CRAVE Campaigns

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AURA ST Meeting
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Boulder, Colorado

TOPICS

1. S-HIS Introduction
2. TES/AIRS Radiance Validation
3. Radiance Closure/ Trop. O_3
   Test using special CRAVE
   sonde profiles
4. Retrievals- T, WV in the field
5. Thin Cirrus

UW Scanning HIS: 1998-Present

(HIS: High-resolution Interferometer Sounder, 1985-1998)

Characteristics

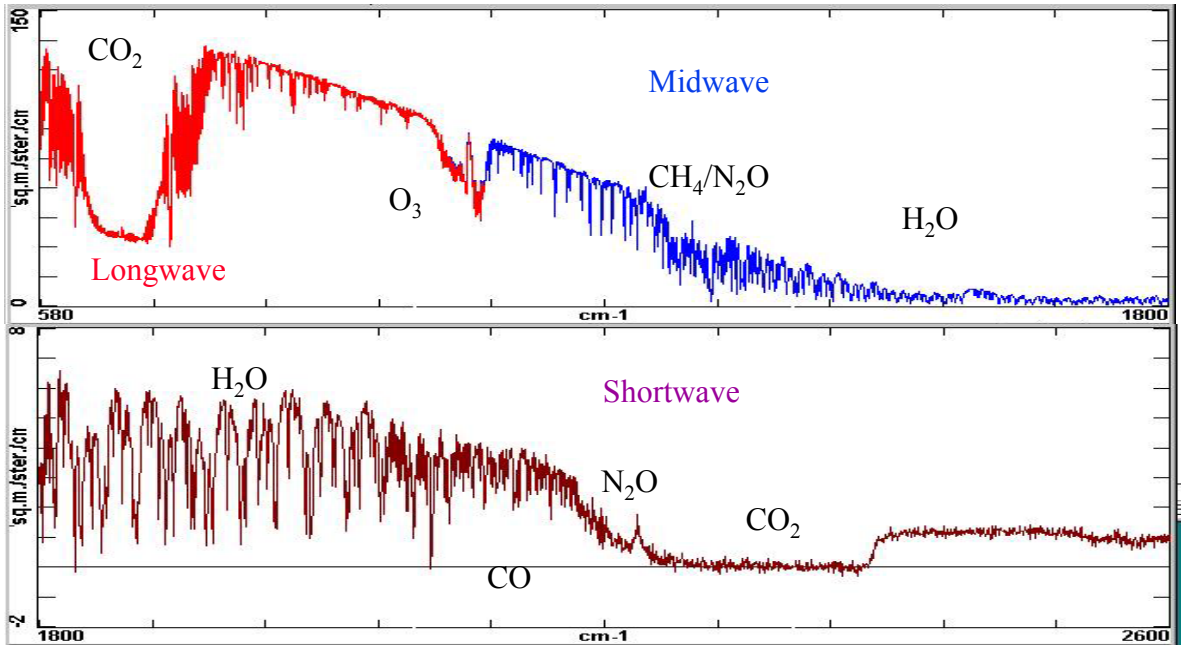
Spectral Coverage: 3-17 microns

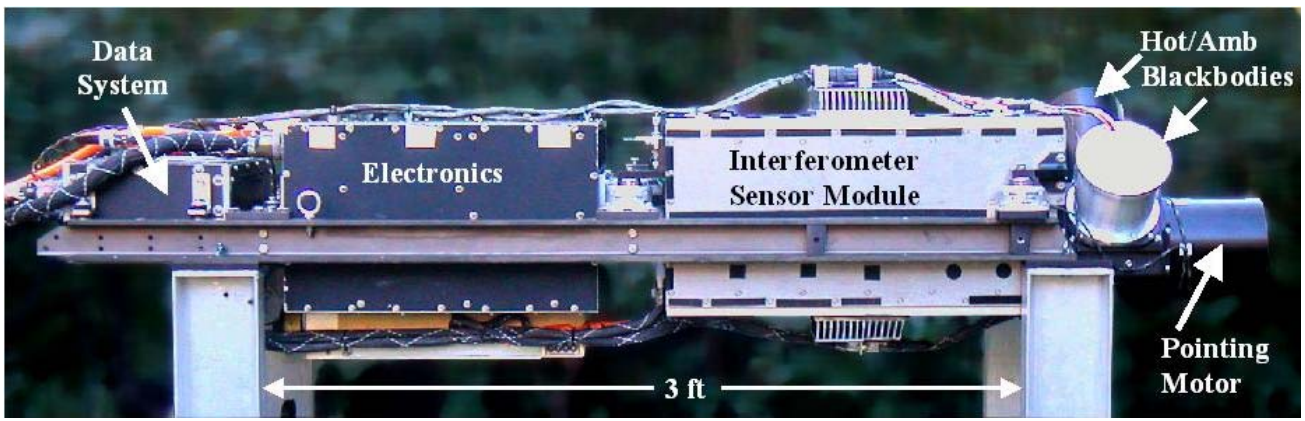
Spectral Resolution: 0.5 cm^{-1}

Resolving power: 1000-6000

Footprint Diam: 1.5 km @ 15 km

Cross-Track Scan: Programmable including uplooking zenith view





Applications:

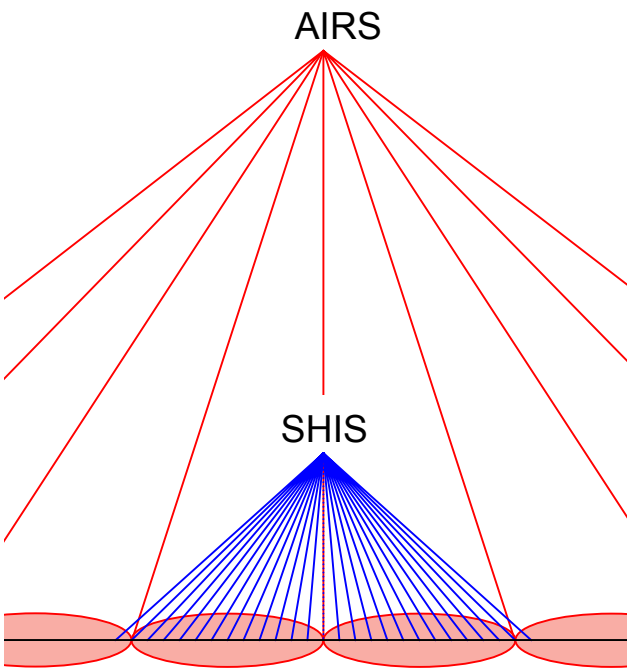
- Radiances for Radiative Transfer
- Temp & Water Vapor Retrievals
- Cloud Radiative Prop.
- Surface Emissivity & T
- Trace Gas Retrievals

S-HIS zenith and cross-track scanning Earth views 11-16-2002 from Proteus @ ~14km

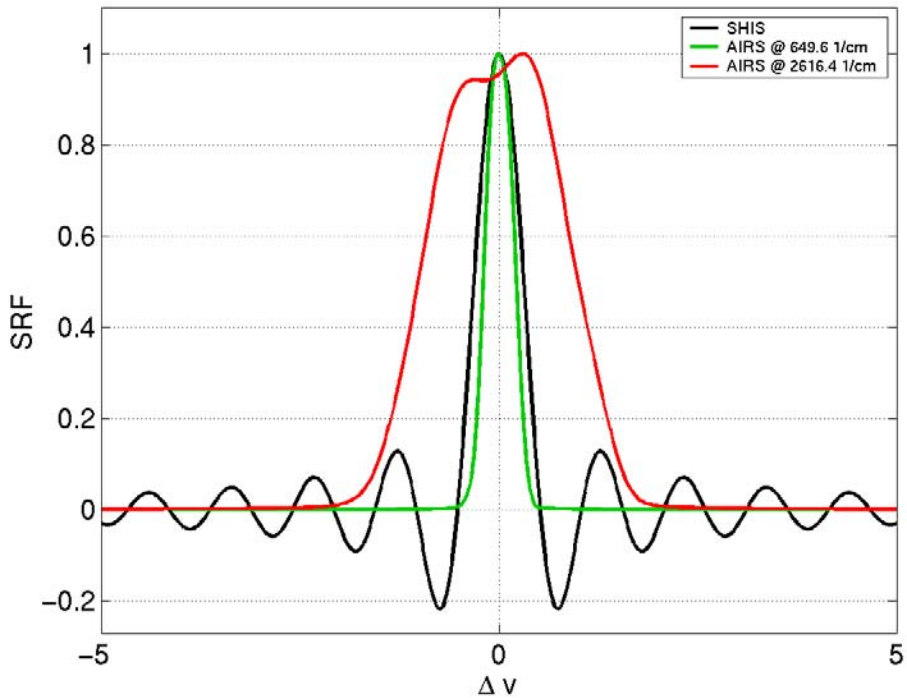
AIRS / SHIS Comparisons

A proper comparison should account for:

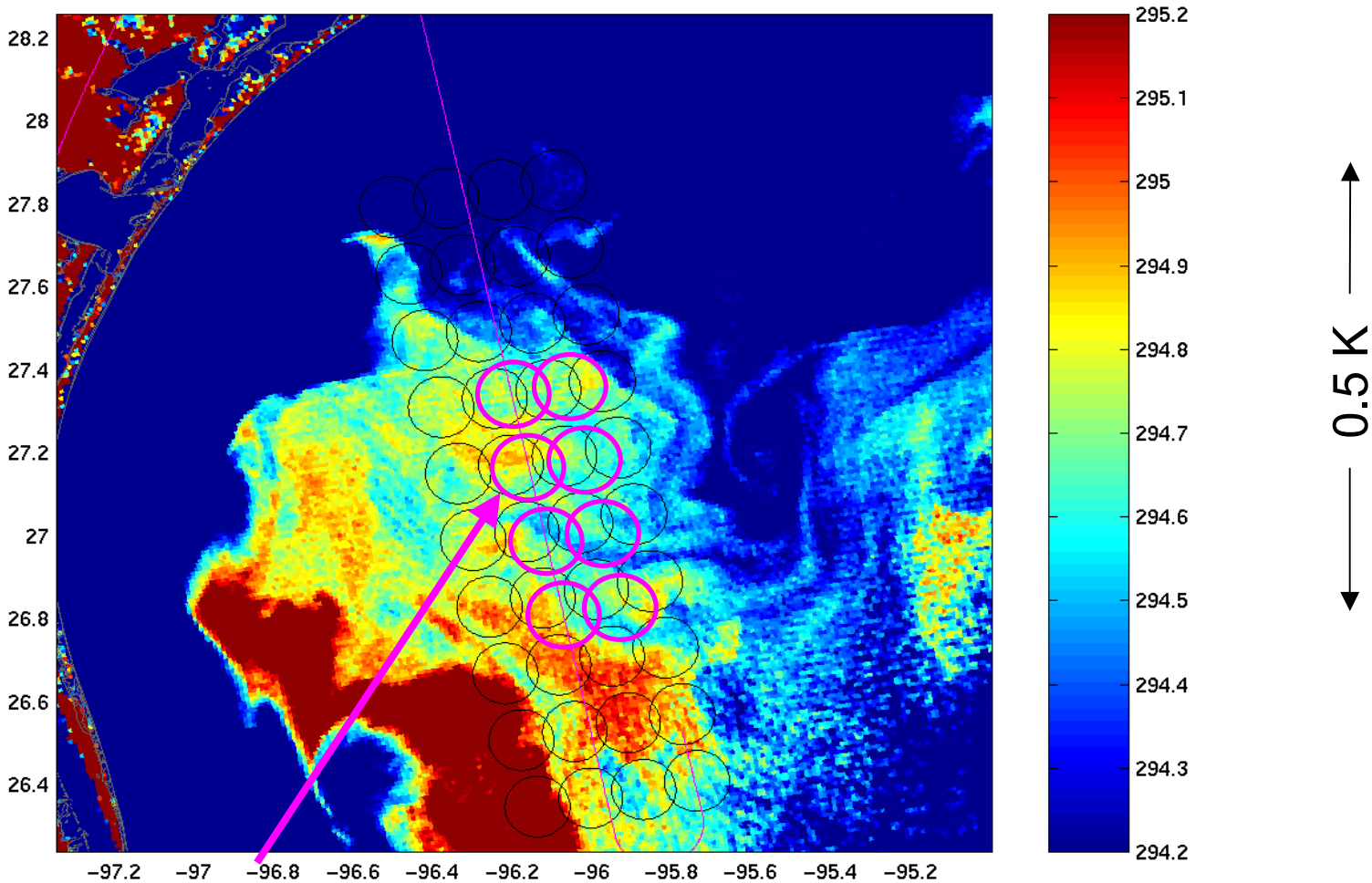
- instrumental noise and scene variations
- Different observation altitudes: **AIRS**: 705km **SHIS:** ~20km
- " view angles ~ nadir ~ ±35deg from nadir
- " spatial footprints ~ 15km at nadir ~ 2km at nadir
- " spectral response $\Delta\nu = \nu/1200$ $\Delta\nu = \sim 0.5\ cm^{-1}$



SHIS and AIRS SRFs



MODIS 12 micron Brightness Temperatures



8 AIRS FOVs used in the following comparisons (near nadir)

448 SHIS FOVs

UWisc Comparison Approach

Common Spectral Basis:

- **AIRS:** convolve with SHIS Instrument Function (IF)
- **SHIS:** convolve with AIRS Instrument Function

Common Spatial Basis:

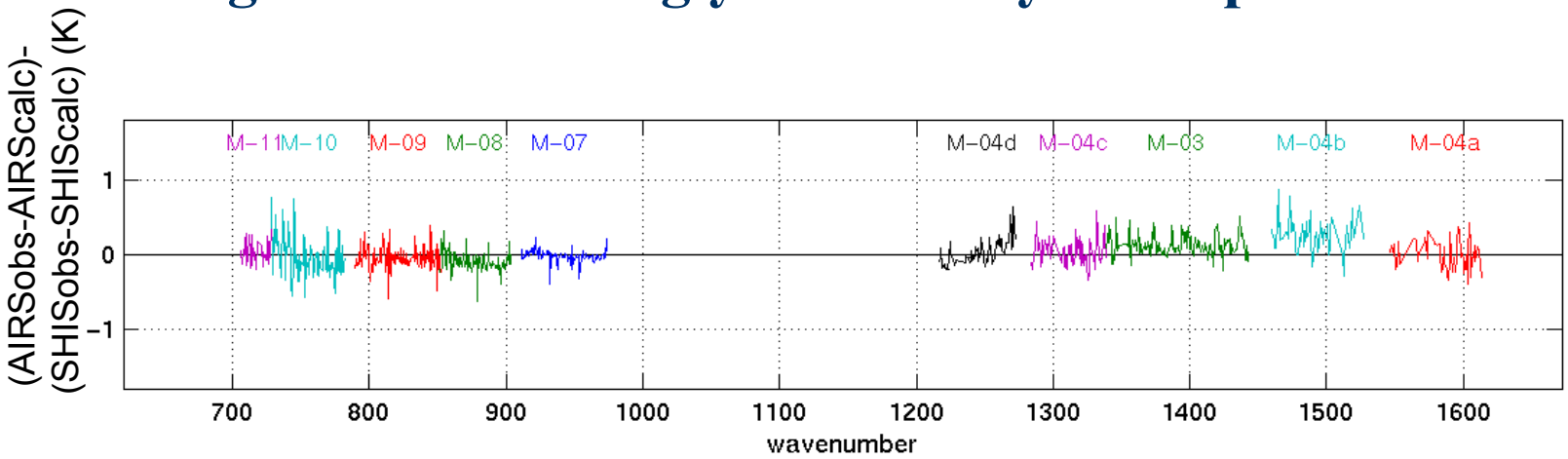
- Assume a specification of atmospheric state (sonde, ecmwf)
- LBL_AIRS
  - LBLRTM spectral radiance for each FOV associated with AIRS
  - Convolve with AIRS IF, then SHIS IF
  - Average over common spatial domain
- LBL_SHIS
  - LBLRTM spectral radiance for each FOV associated with SHIS
  - Convolve with SHIS IF, then AIRS IF
  - Average over common spatial domain

Comparison:

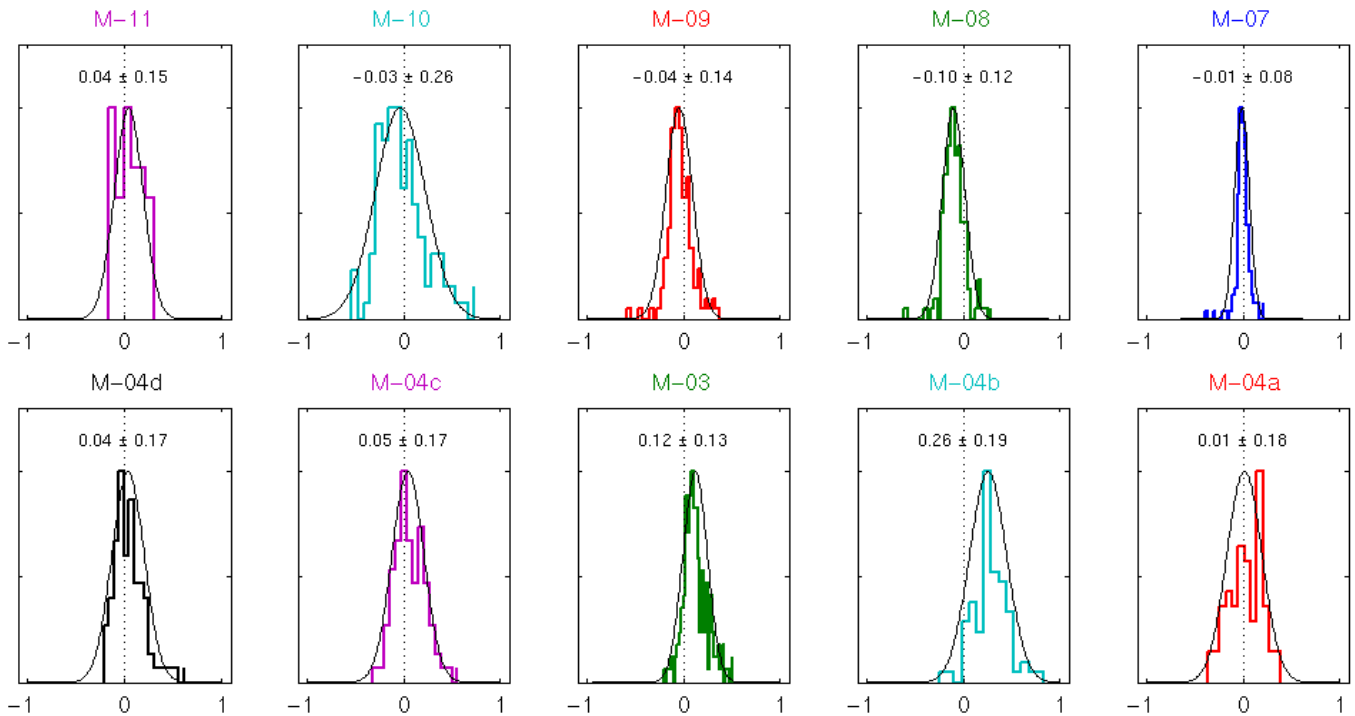
$$\frac{(\text{AIRS} - \text{LBL\_AIRS}) - (\text{SHIS} - \text{LBL\_SHIS})}{\{\text{AIRS} - \text{SHIS}\} - [\text{LBL\_AIRS} - \text{LBL\_SHIS}]}$$

correction term

AIRS / SHIS Brightness Temperature Comparison
Excluding channels strongly affected by atmosphere above ER2

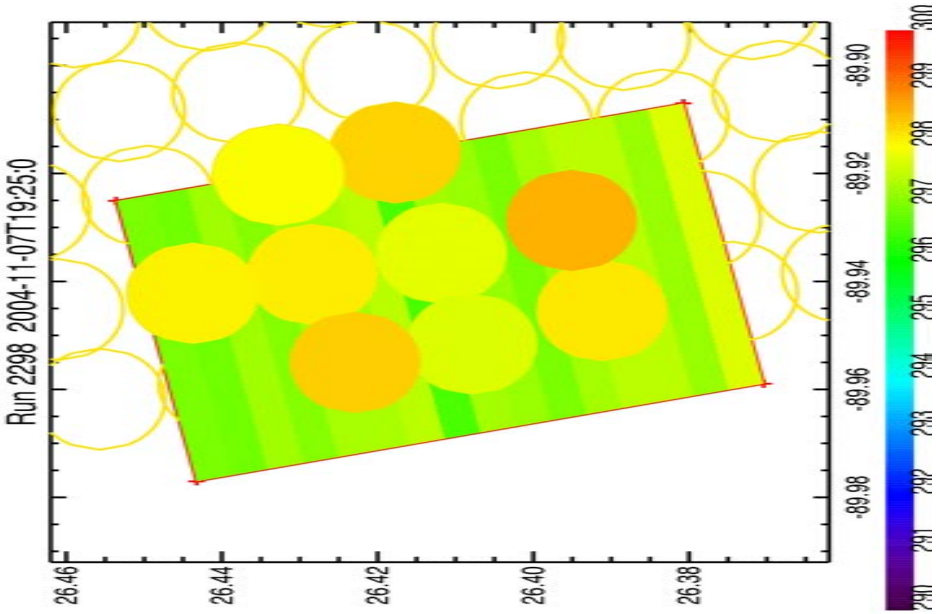


Histograms



Aura Validation Experiment: Nov. 7, 2004 : Gulf of Mexico

AVE Observations to Investigate Line-by-line Calculations



Brightness Temperature (K) @ 1105 cm $^{-1}$

SHIS scans - averaged nine ~2 km circles

TES nadir scan - average of the sixteen 0.5 x 5km rectangular pixels from overpass

SHIS : ~ 2 km

Spectral resolution: 0.48 cm^{-1}

TES Underflight

Altitude of 18 km

TES : 8 x 5 km

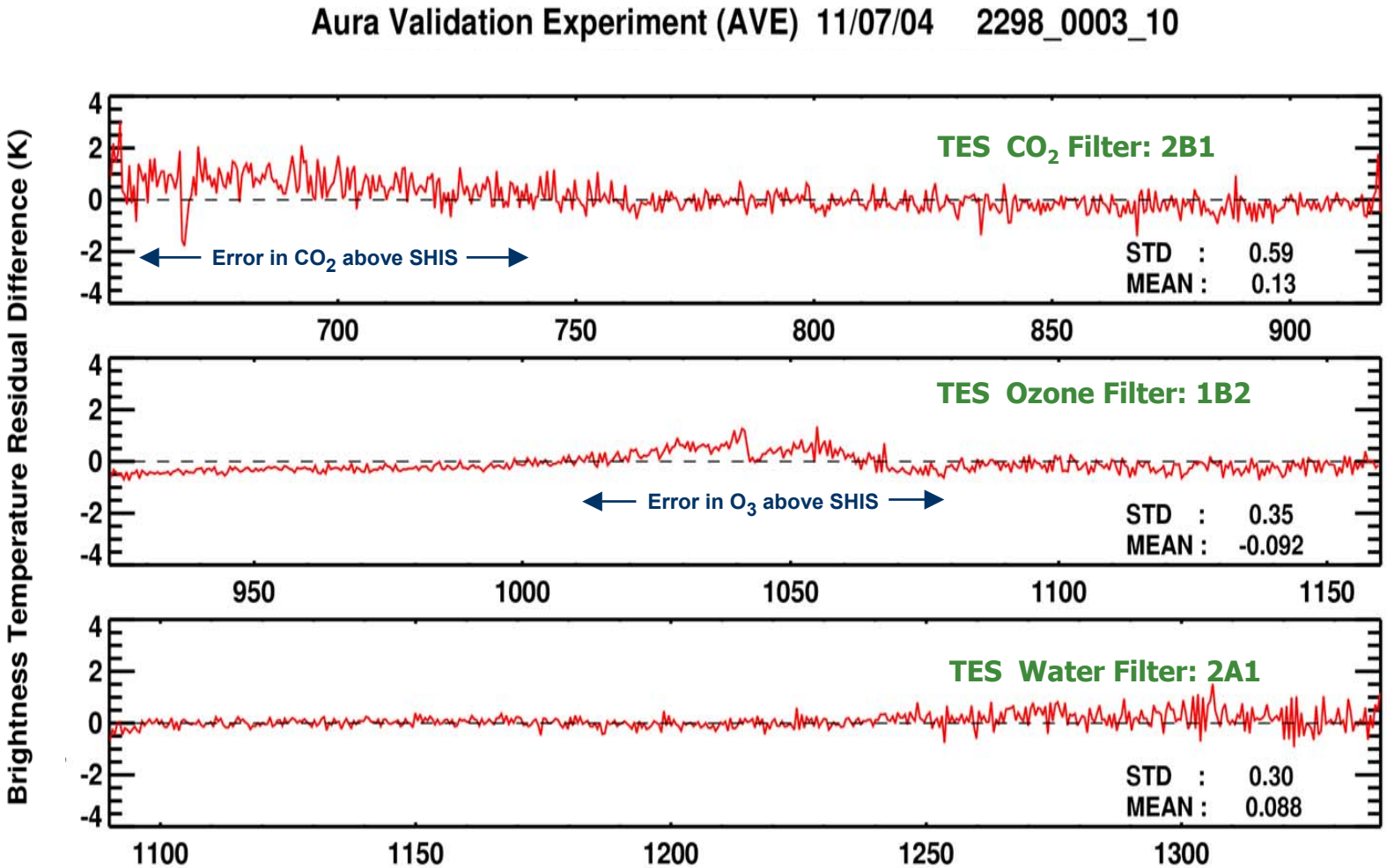
Spectral resolution: 0.06 cm^{-1}

Nadir

19:25 UTC

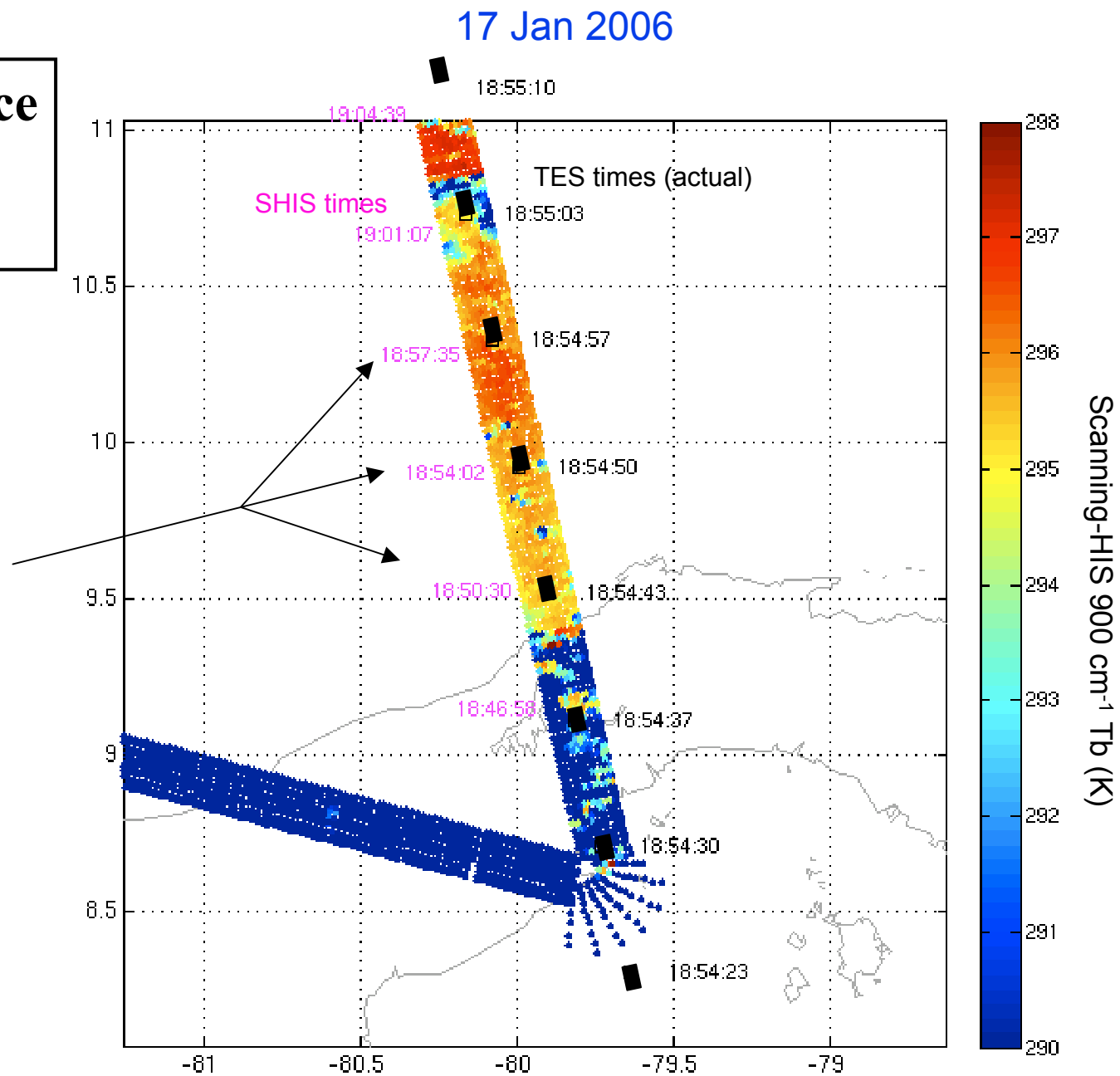
TES - SHIS Radiance Comparison

- **TES Convolved to SHIS ILS**
- **{TES - LBLRTM(TES Geometry)} - {SHIS - LBLRTM(SHIS Geometry)}**

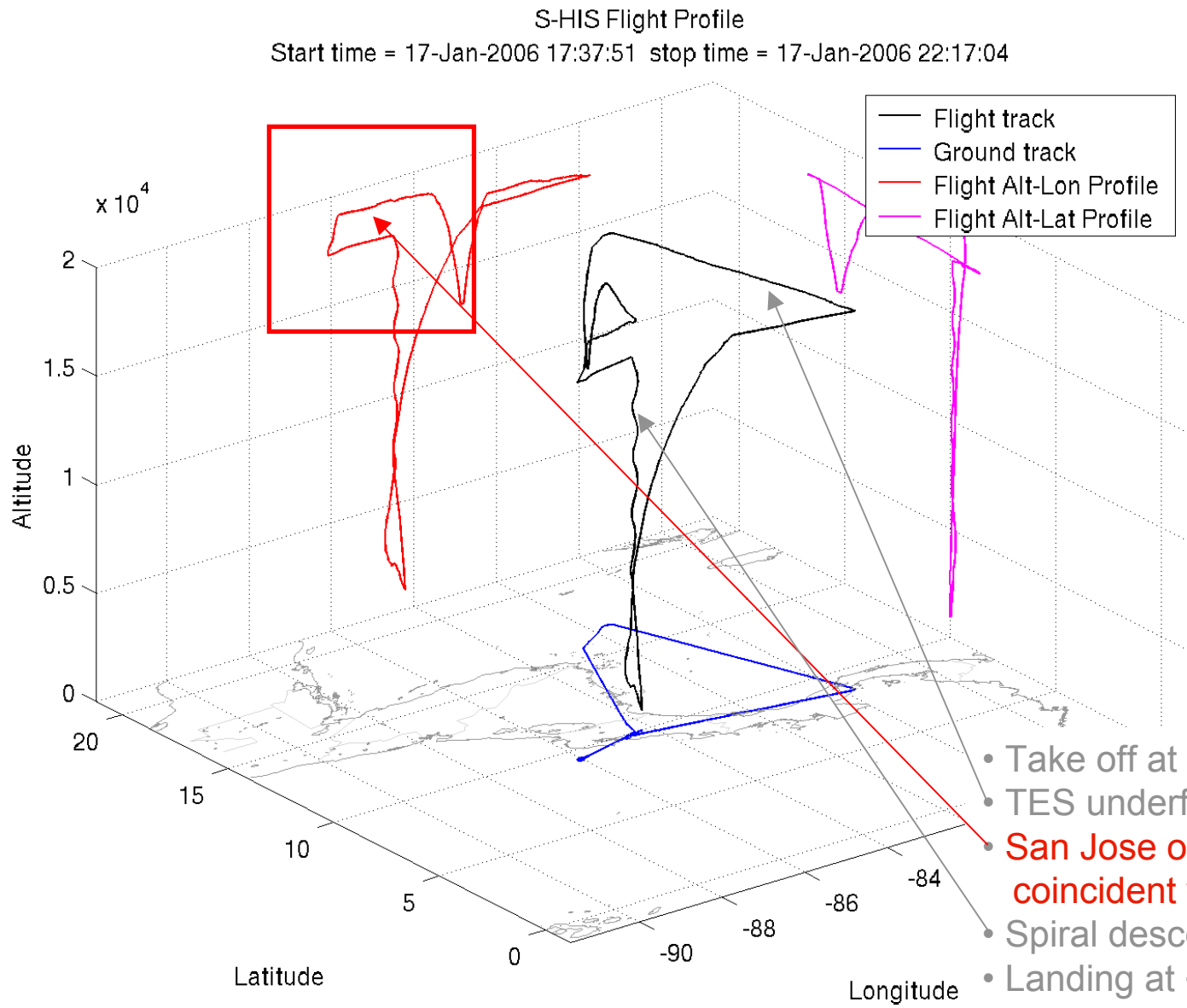


3. Radiance Closure / Trop. O3 Test using special CRAVE sonde profiles

TES Radiance Validation Footprints

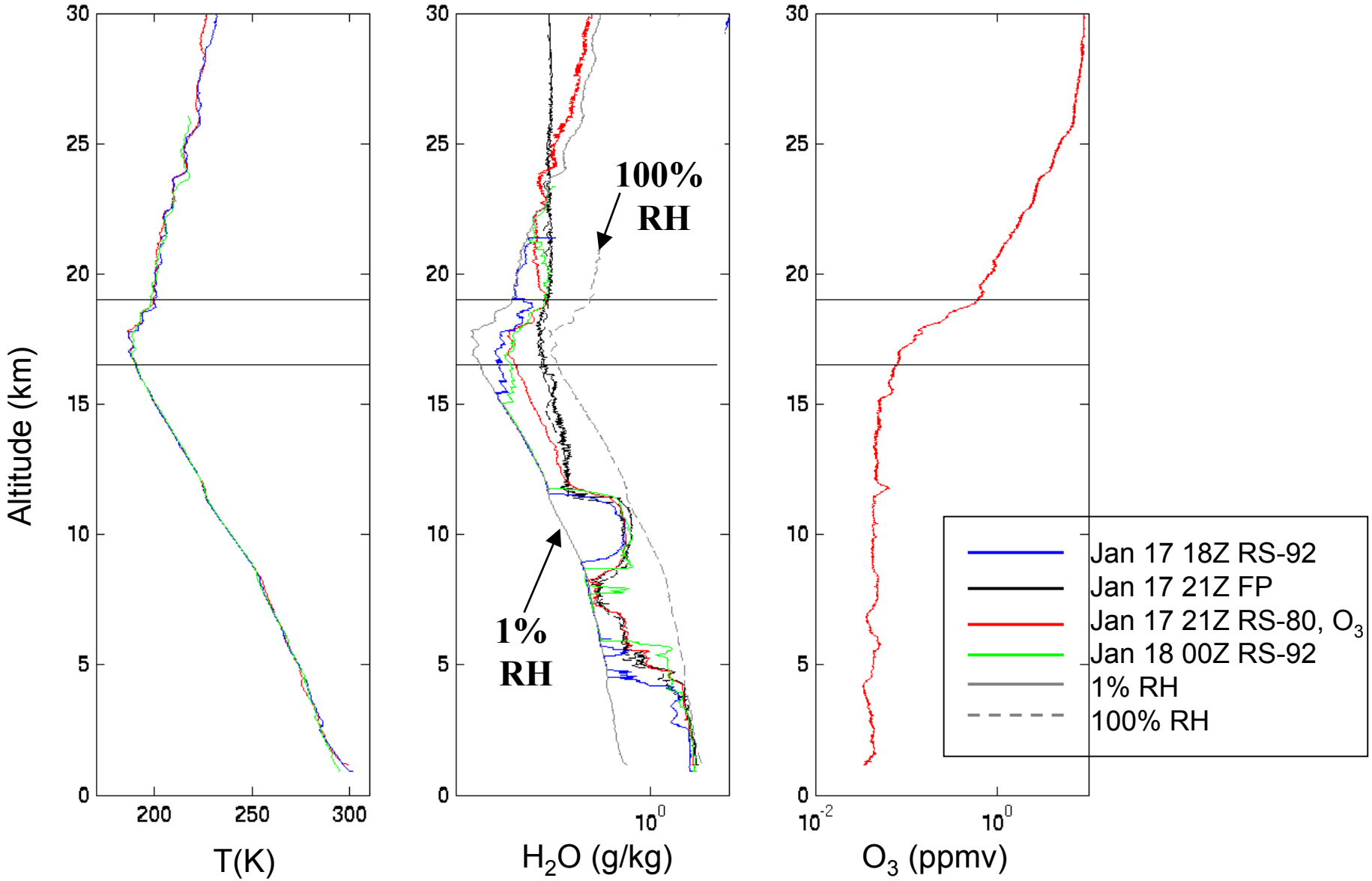


TES/SHIS time & space coincidence



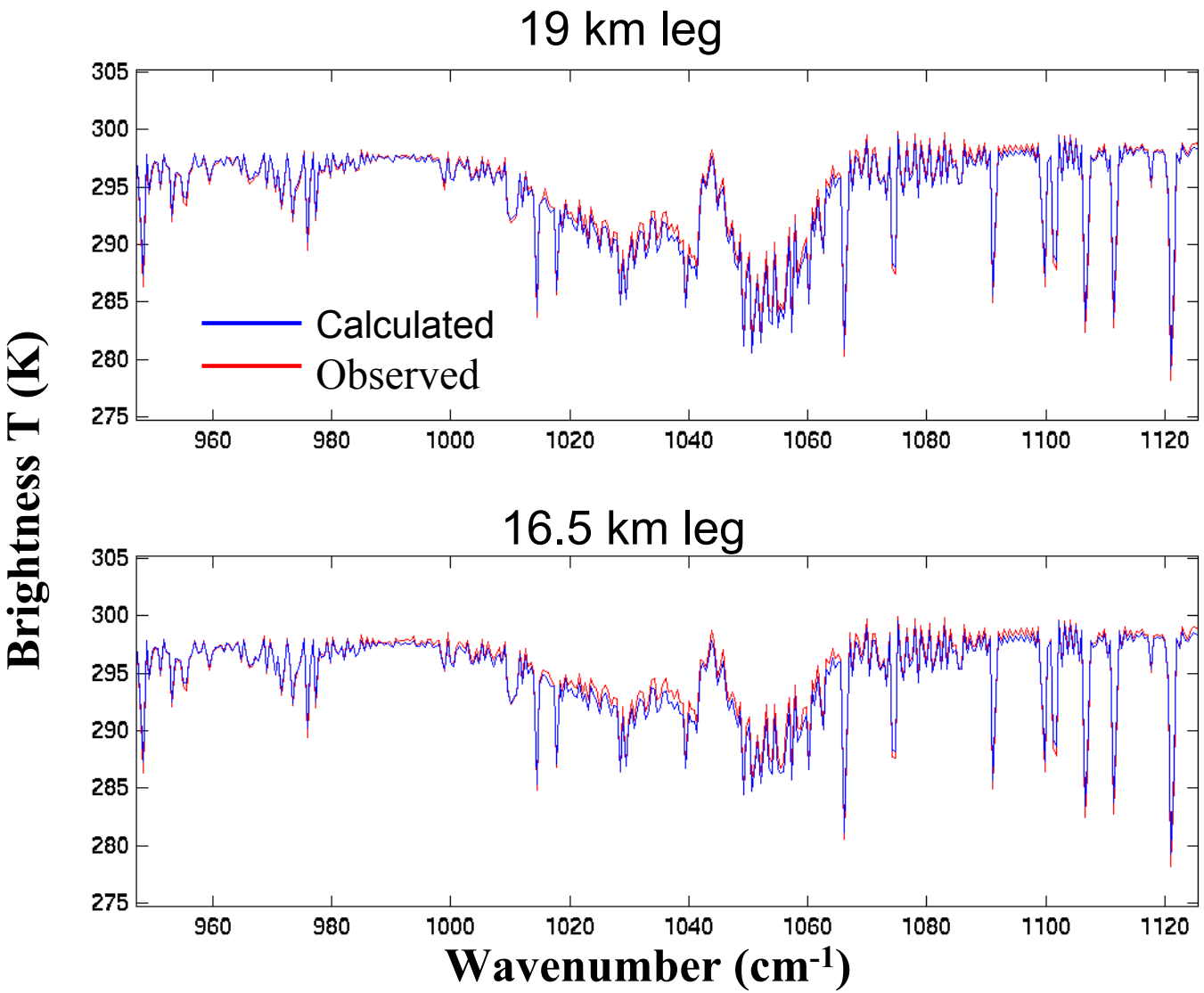
- Take off at ~17:37
- TES underflight at ~18:55
- San Jose overpass coincident w/ sonde launches
- Spiral descent over San Jose
- Landing at ~22:17

Tico / Vomel Sonde Data: 17 January



9.6 micron Ozone Band Tb(K):

Direct Comparison of S-HIS and LBLRTM from Sonde



Summary

- **Scanning HIS Instrument Performance has been very good**
- **First CRAVE flight provided useful case for TES/AIRS Radiance validation**
- **Ozone sonde overflights started off well and are expected to provide good radiance closure and tropospheric O_3 retrieval tests**
- **Very thin cirrus (ferry flight & 19 January) are not detected in S-HIS uplooking-careful inspection of downlooking is more likely to provide detection**

Scanning-HIS Radiometric Calibration Budget

TABB= 227, THBB=310, 11/16/02 Proteus

Similar to AERI description in Best, et al., CALCON 2003

3-sigma Tb error < 0.3 K for Tb >220 K

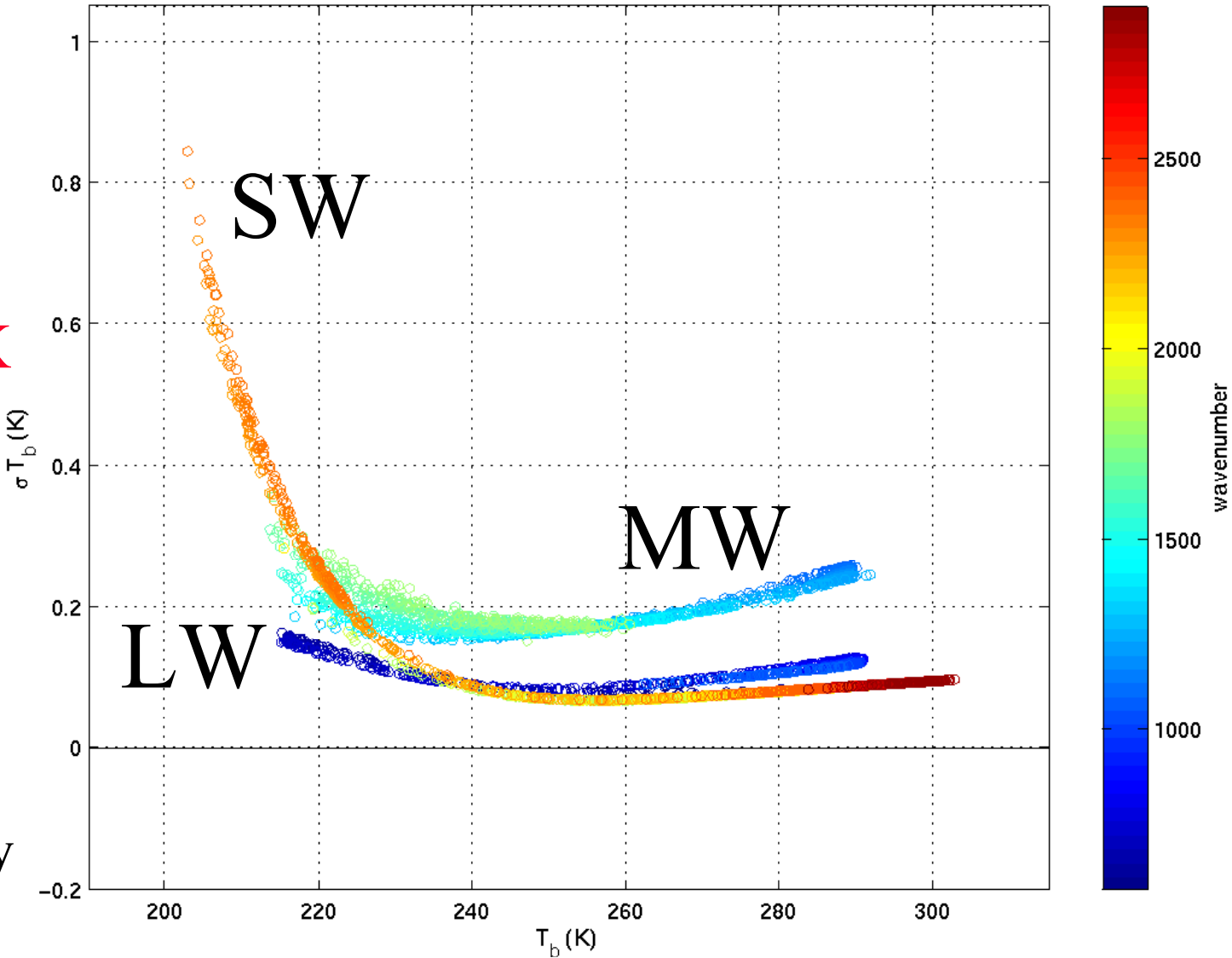
RSS of Errors in

T_{HBB}, T_{ABB}

T_{Rfl}

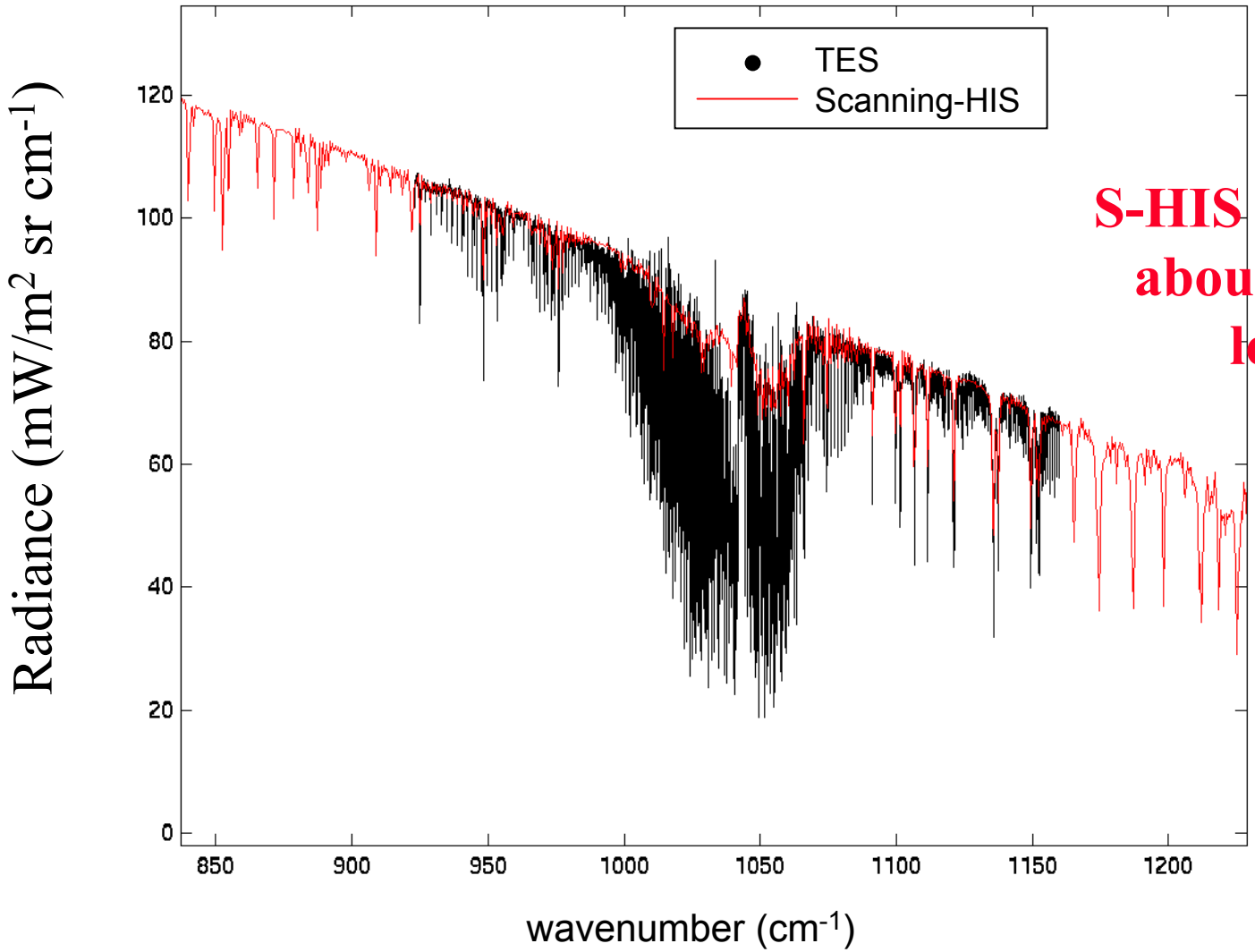
ε_{HBB}, ε_{ABB}

+ 10% of non-linearity correction



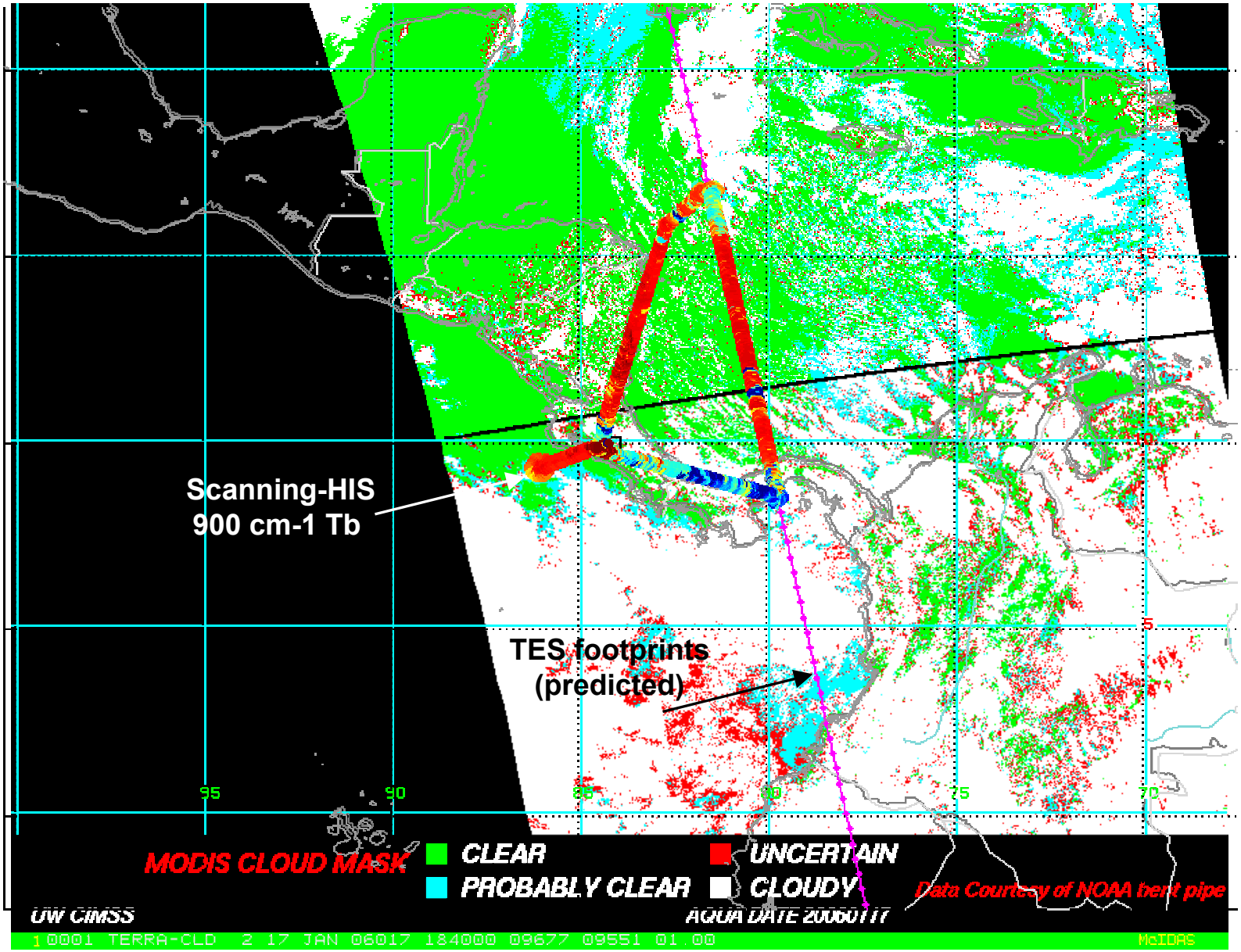
S-HIS Ozone Band compared to TES

Preliminary-CRAVE Flight 1/17/06



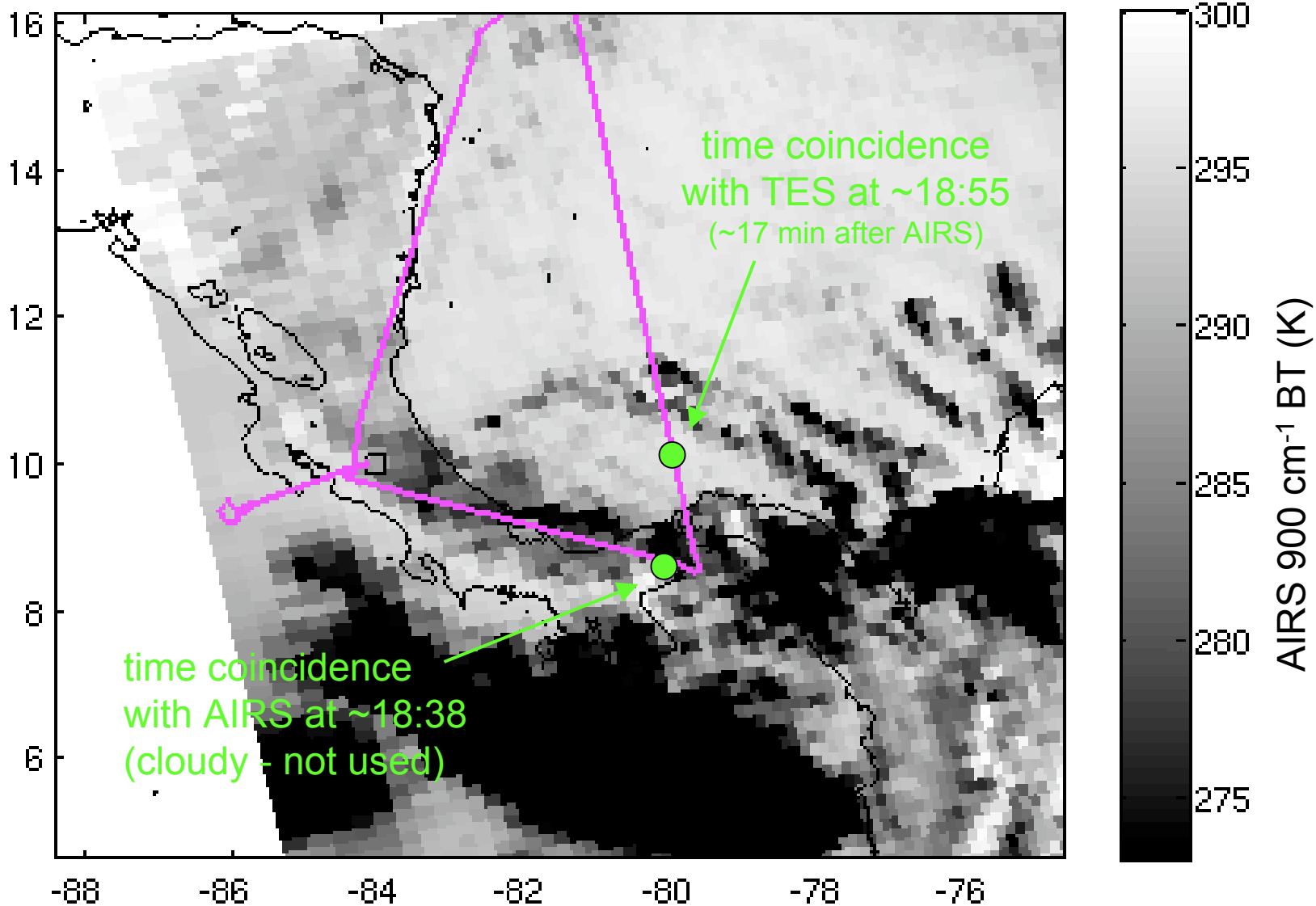
S-HIS resolution about 8 times lower

17 Jan 2006. Aqua MODIS Cloud Mask

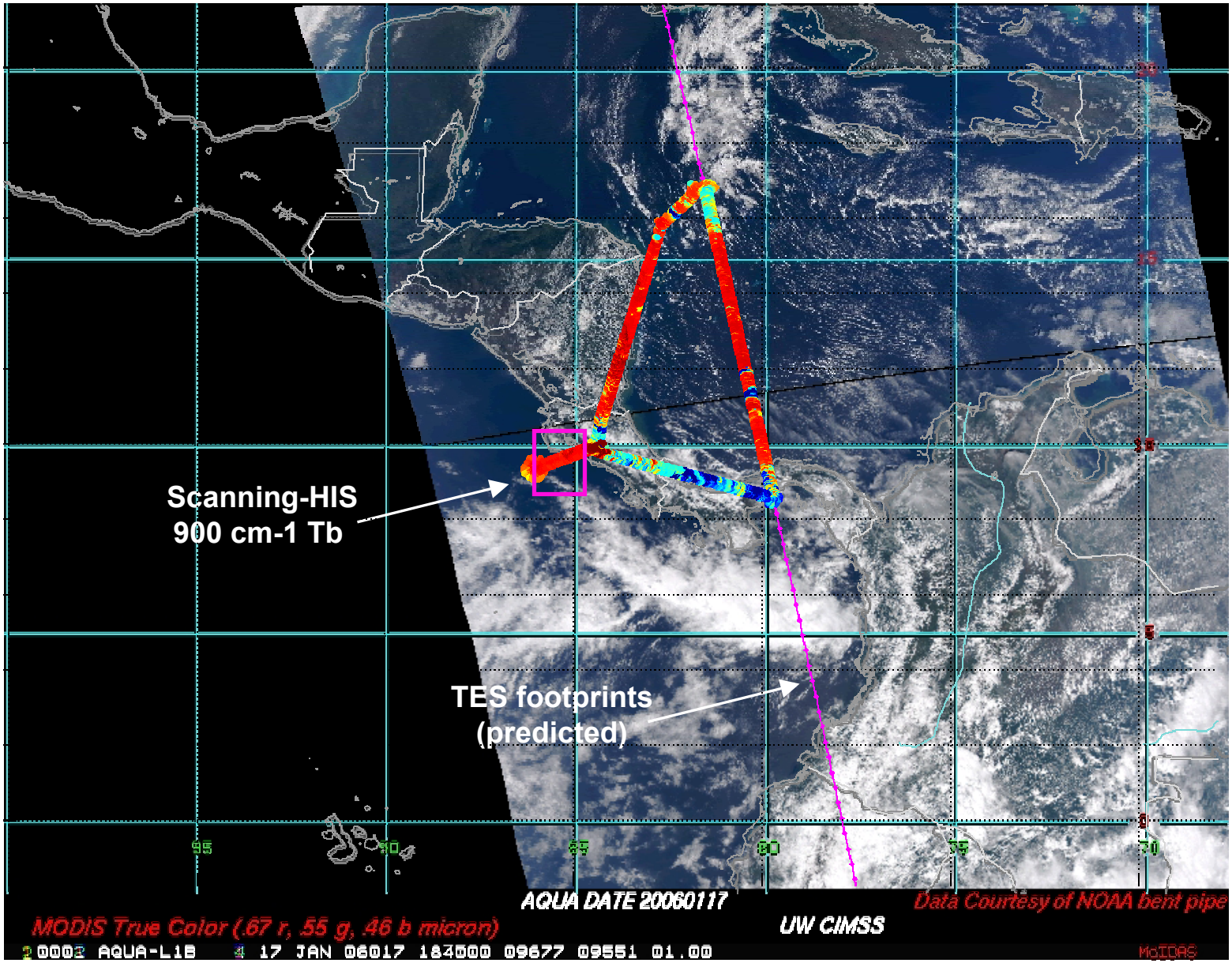


AIRS Data for 17 January Flight

showing coincidence & clear analysis point (17 min later)

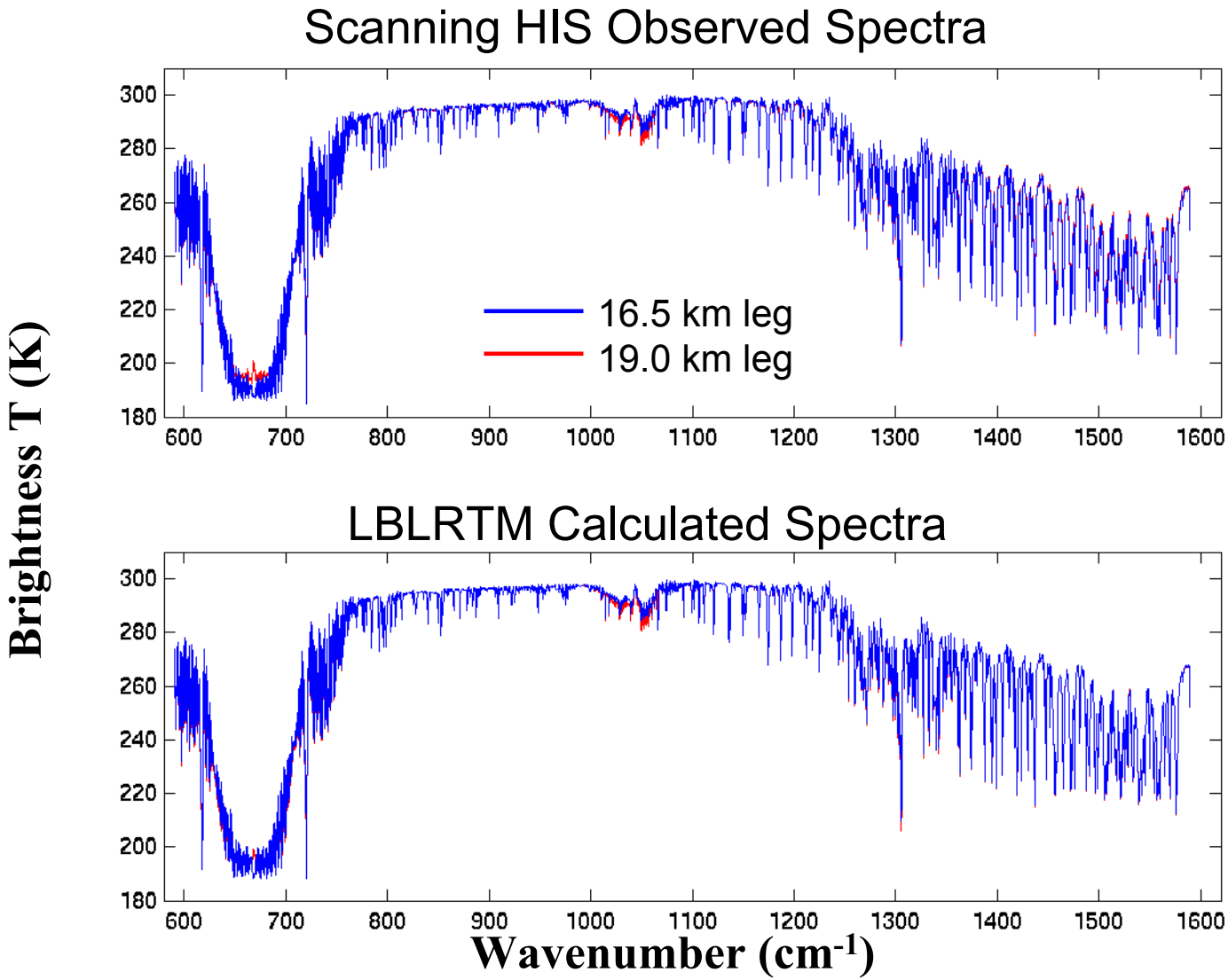


17 Jan 2006. Aqua MODIS Visible RGB image



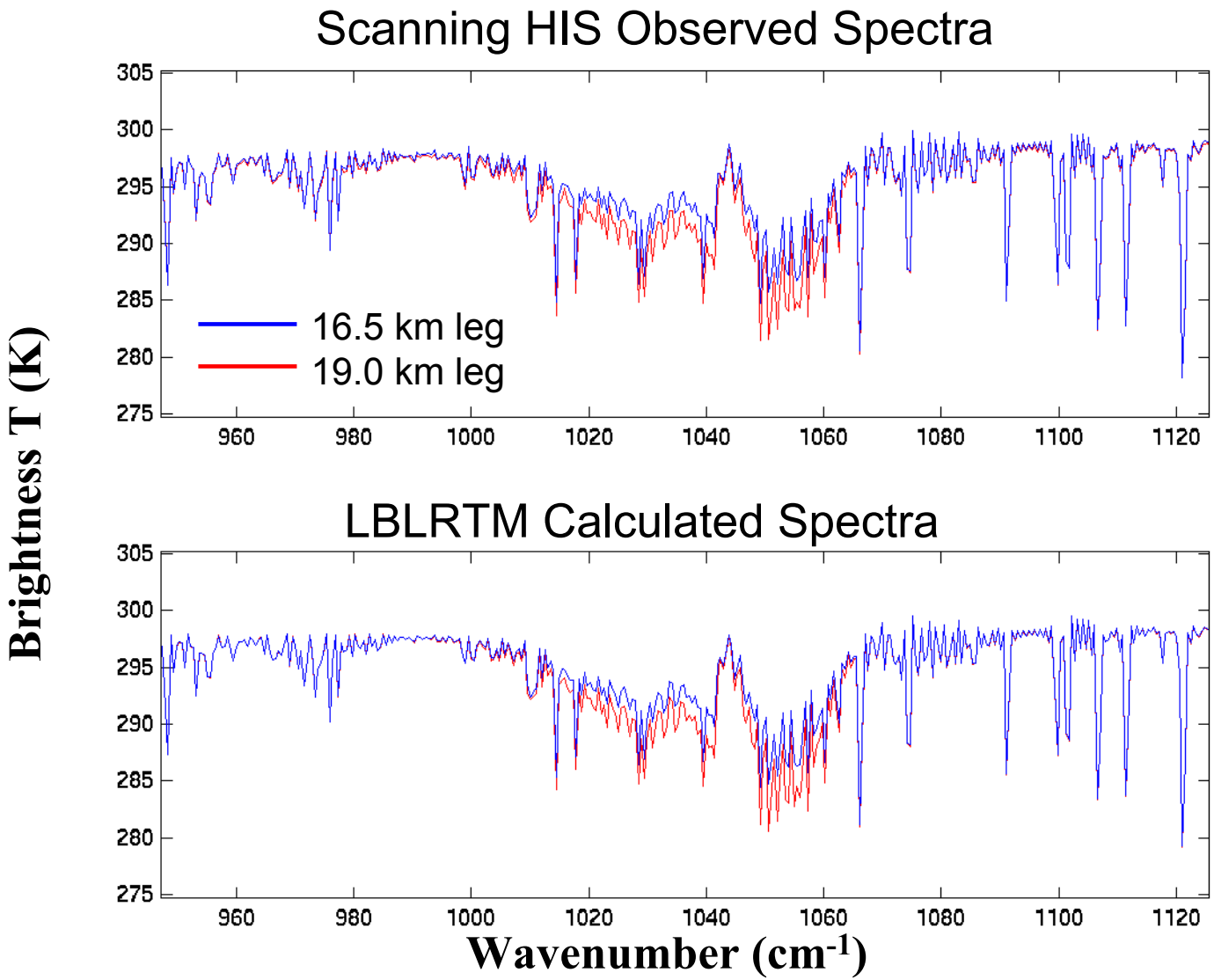
LW & MW Band T_b(K):

S-HIS/S-HIS and Calculated/Calc Dual Leg Comparison

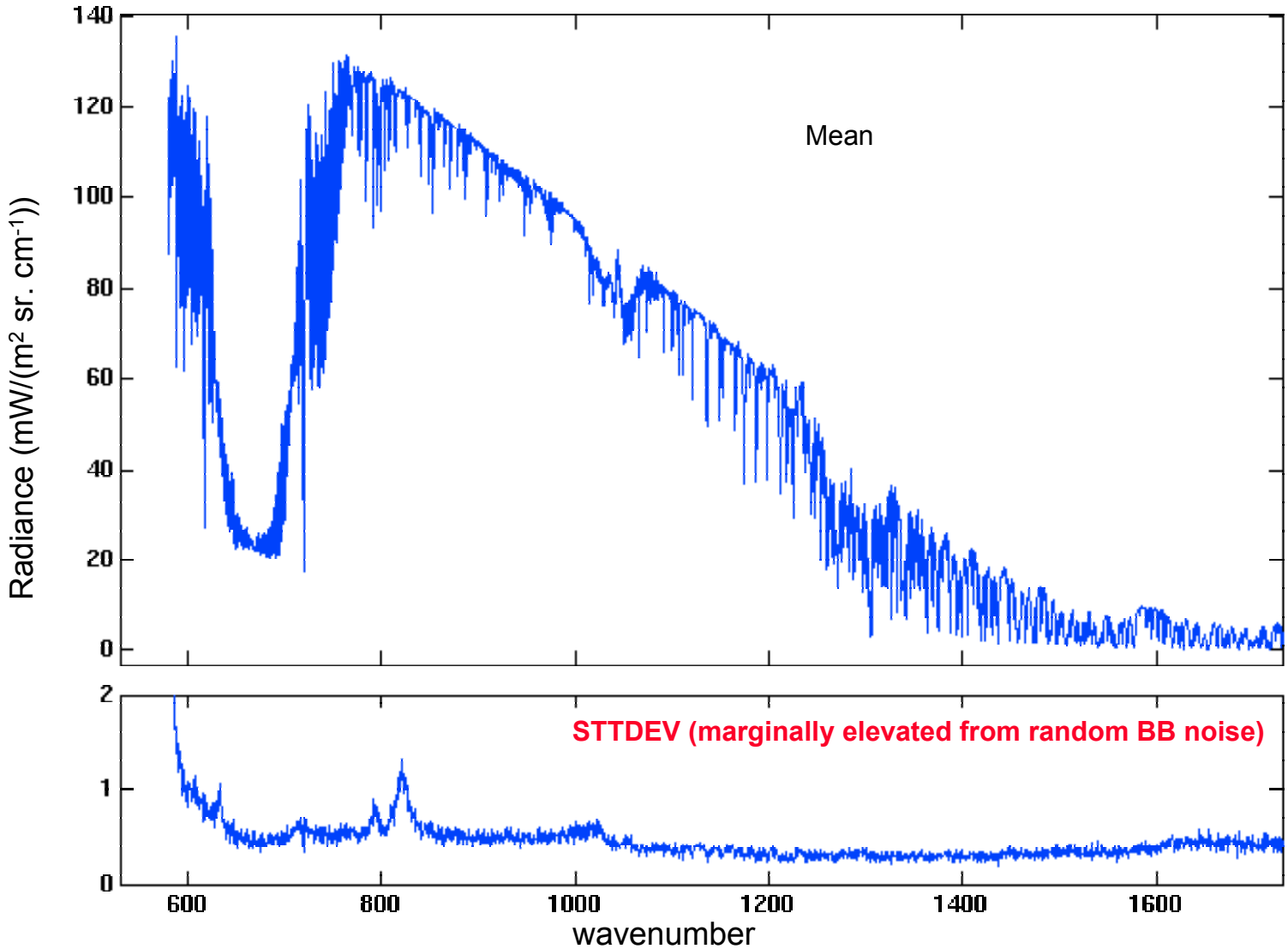


9.6 micron Ozone Band Tb(K):

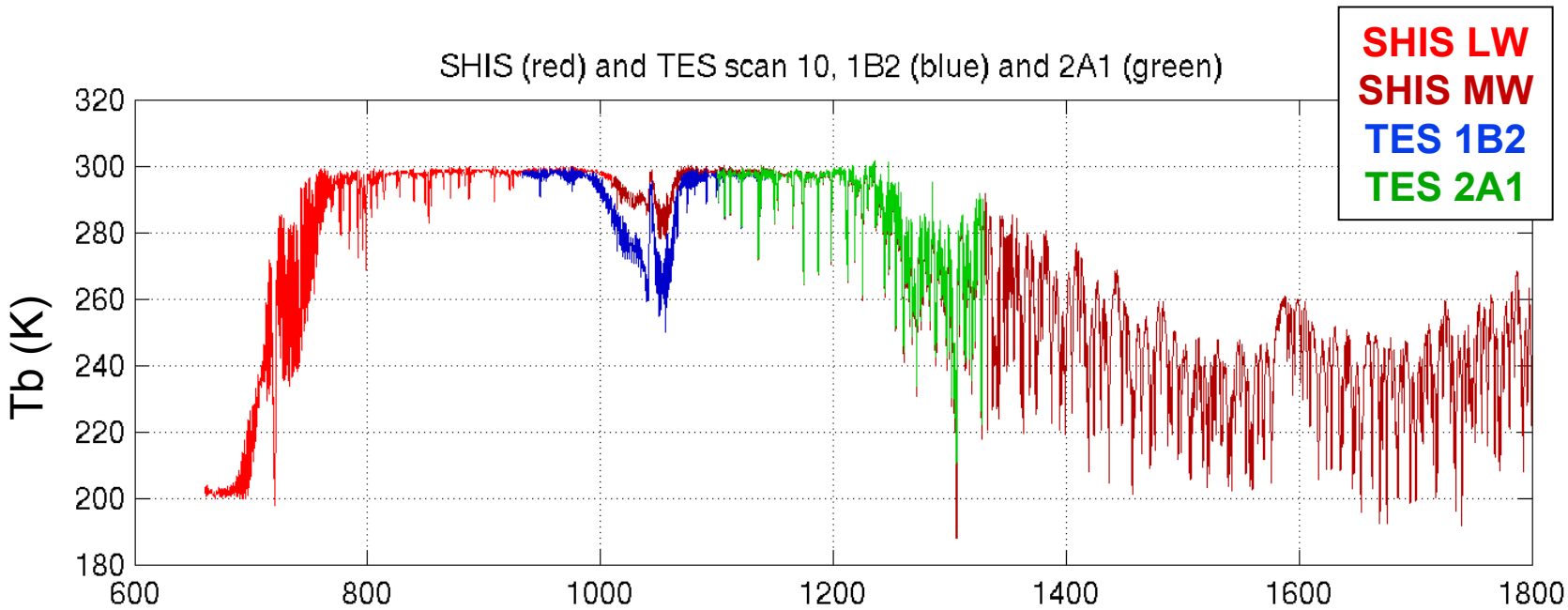
S-HIS/S-HIS and Calculated/Calc Dual Leg Comparison



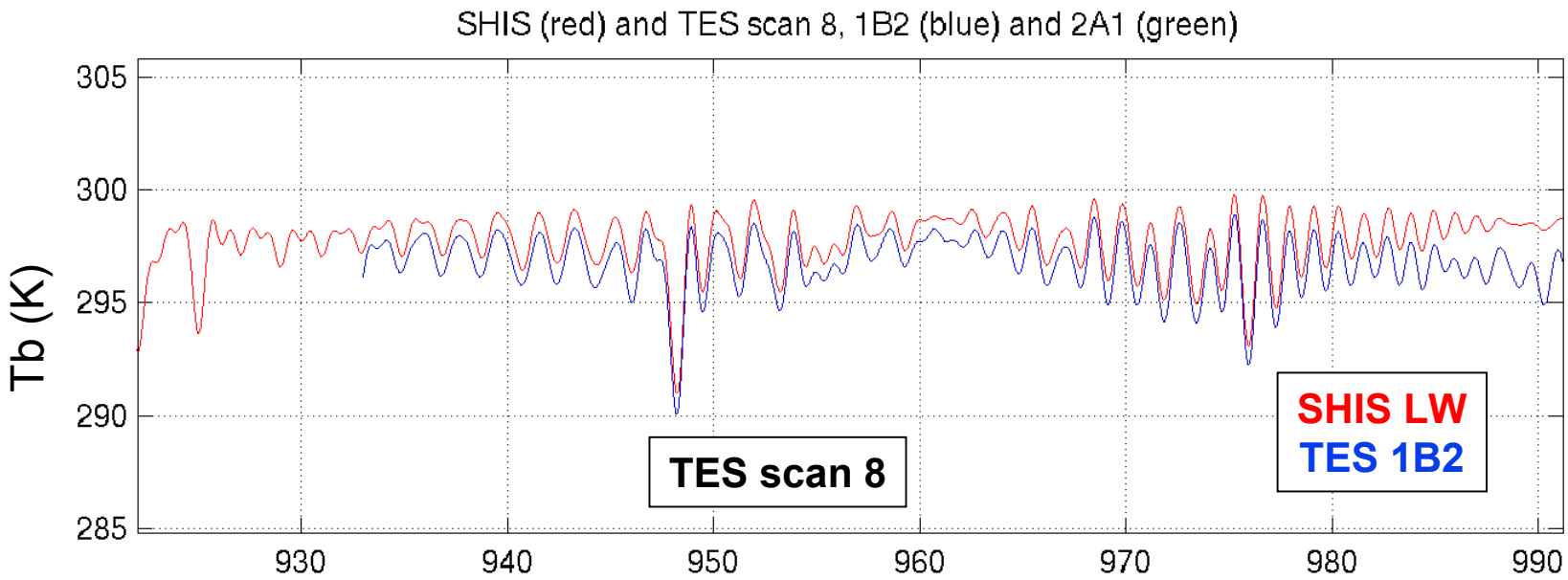
Mean and STDDEV Scanning-HIS spectrum for FOVs w/in 5 km of center of 17 Jan 2006 18:54:54 TES footprint

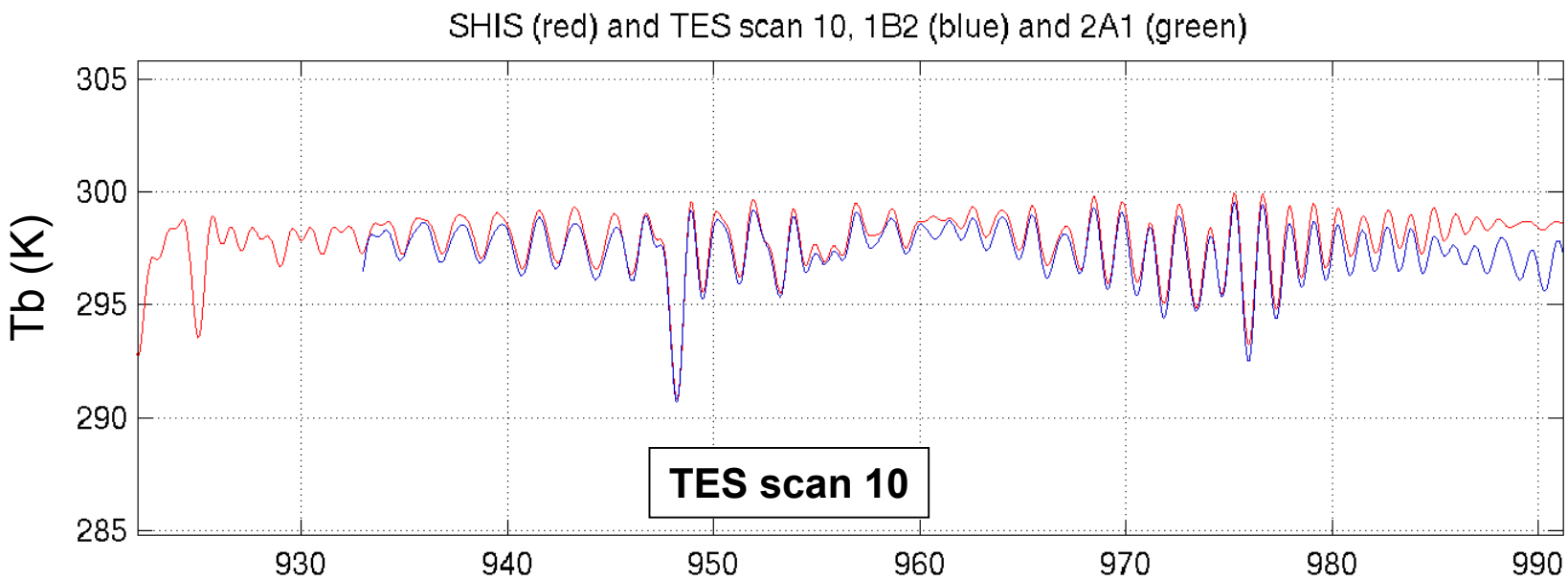


TES spectral resolution reduced x8 for comparison to S-HIS (AVE 2004)

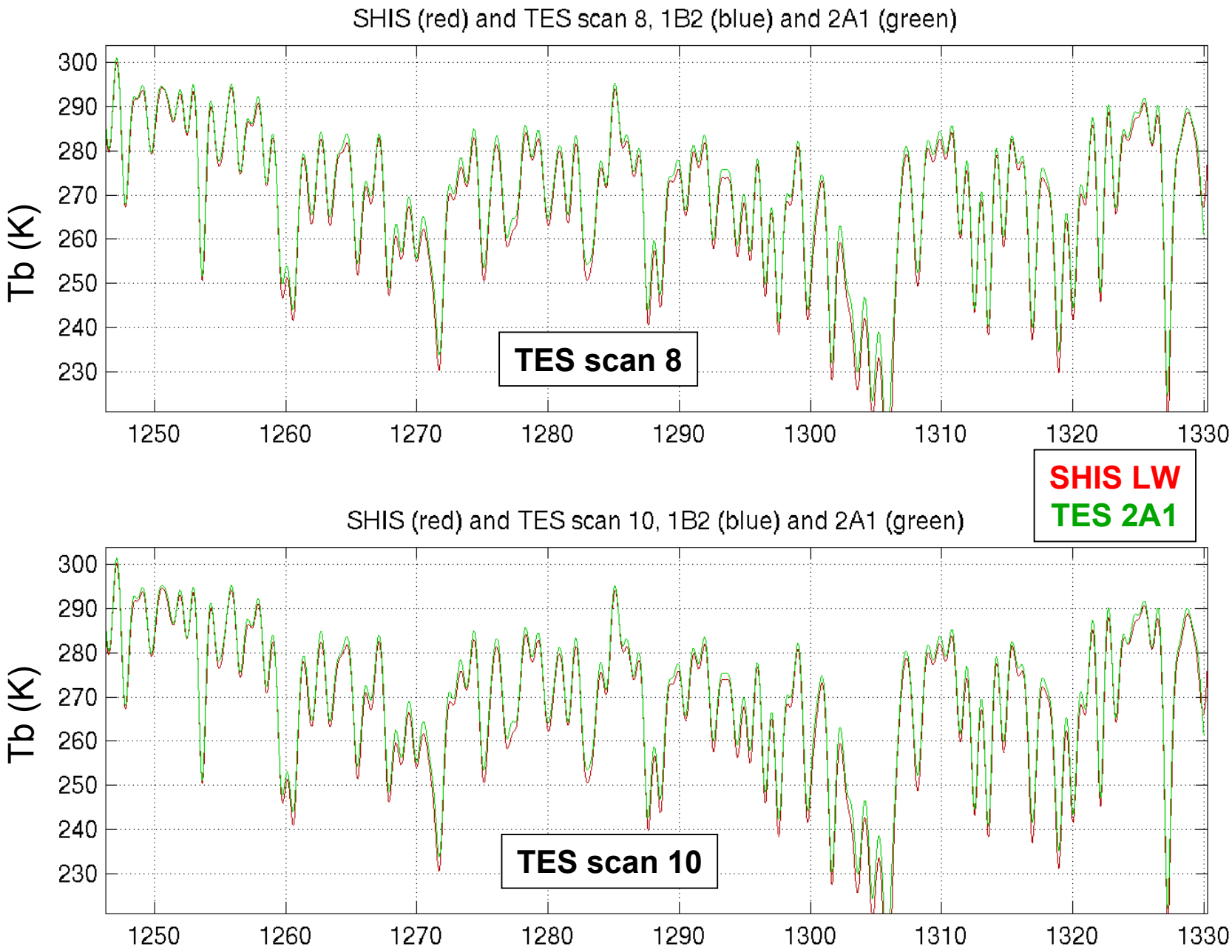


Both at S-HIS spectral resolution (0.5 cm^{-1}) and oversampled


SHIS (red) and TES scan 8, 1B2 (blue) and 2A1 (green)
Tb (K)
305
300
295
290
285
930
940
950
960
970
980
990
TES scan 8
SHIS LW
TES 1B2

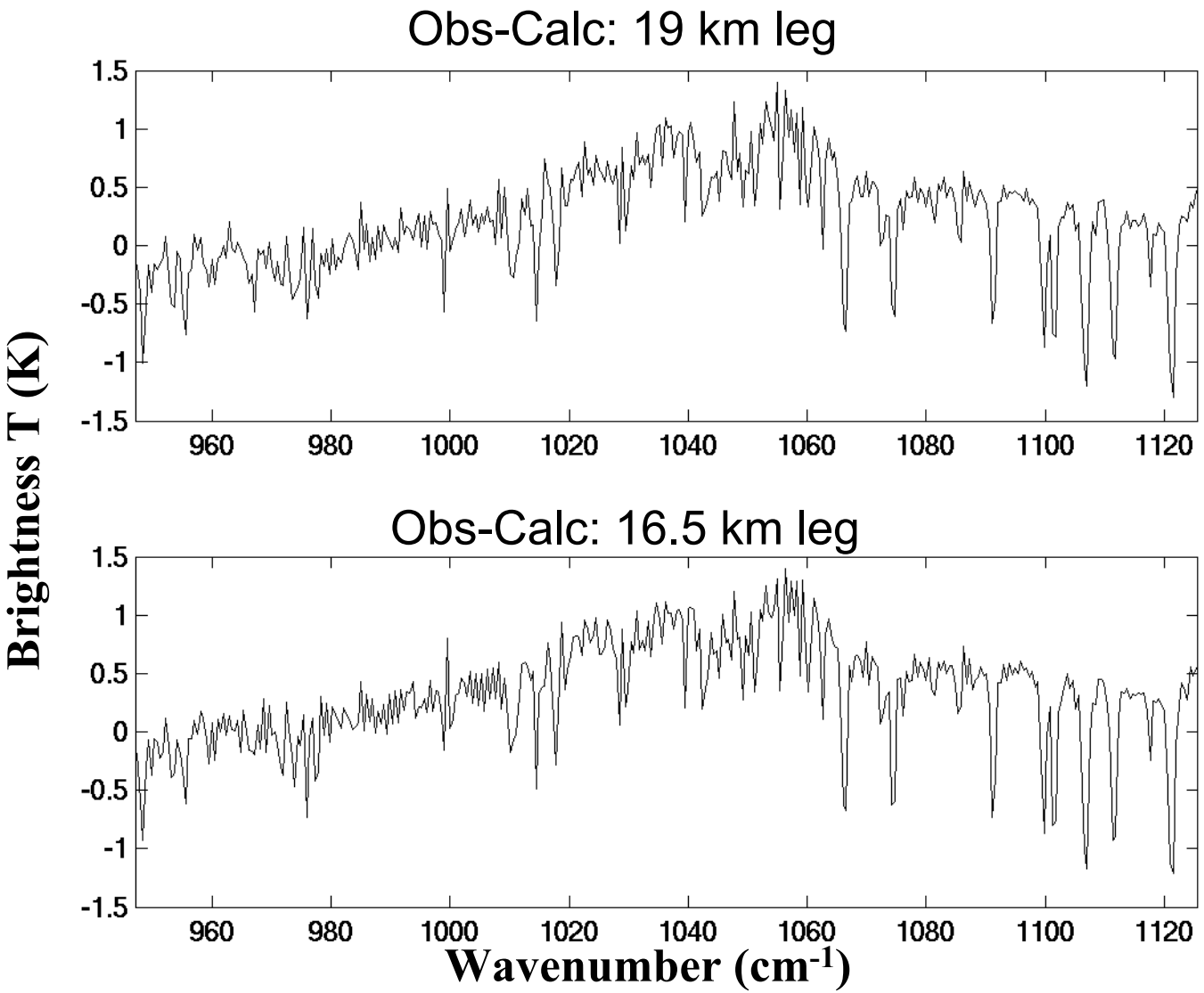

SHIS (red) and TES scan 10, 1B2 (blue) and 2A1 (green)
Tb (K)
305
300
295
290
285
930
940
950
960
970
980
990
TES scan 10

AVE 2004


SHIS (red) and TES scan 8, 1B2 (blue) and 2A1 (green)
Tb (K)
300
290
280
270
260
250
240
230
1250
1260
1270
1280
1290
1300
1310
1320
1330
TES scan 8
SHIS LW
TES 2A1
SHIS (red) and TES scan 10, 1B2 (blue) and 2A1 (green)
Tb (K)
TES scan 10

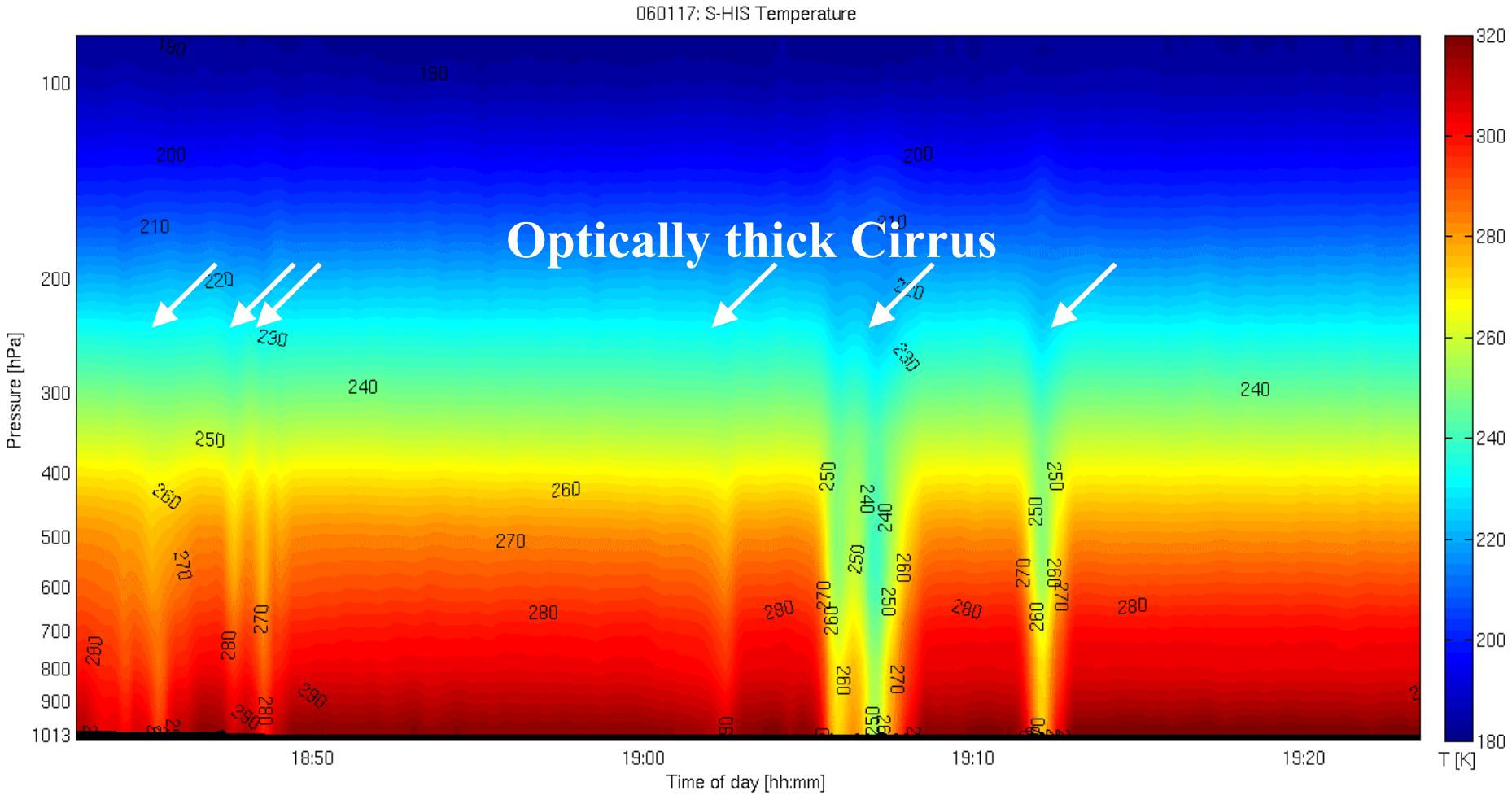
AVE 2004

9.6 micron Ozone Band Tb(K):
S-HIS minus LBLRTM from Sonde

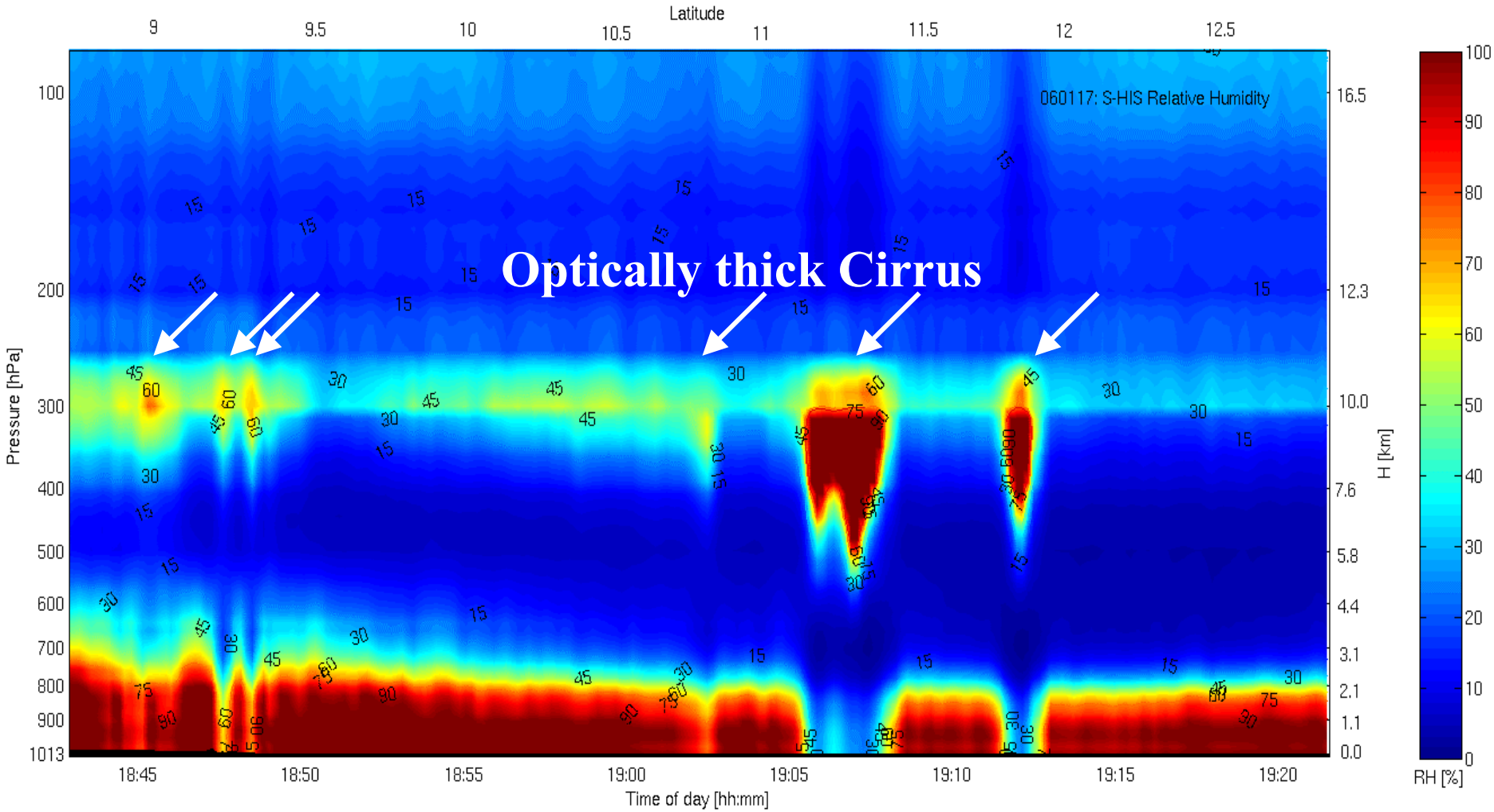


4. Retrieval- T, WV in the field

Scanning HIS Temperature Retrieval
from TES Flight on 17 January 2006

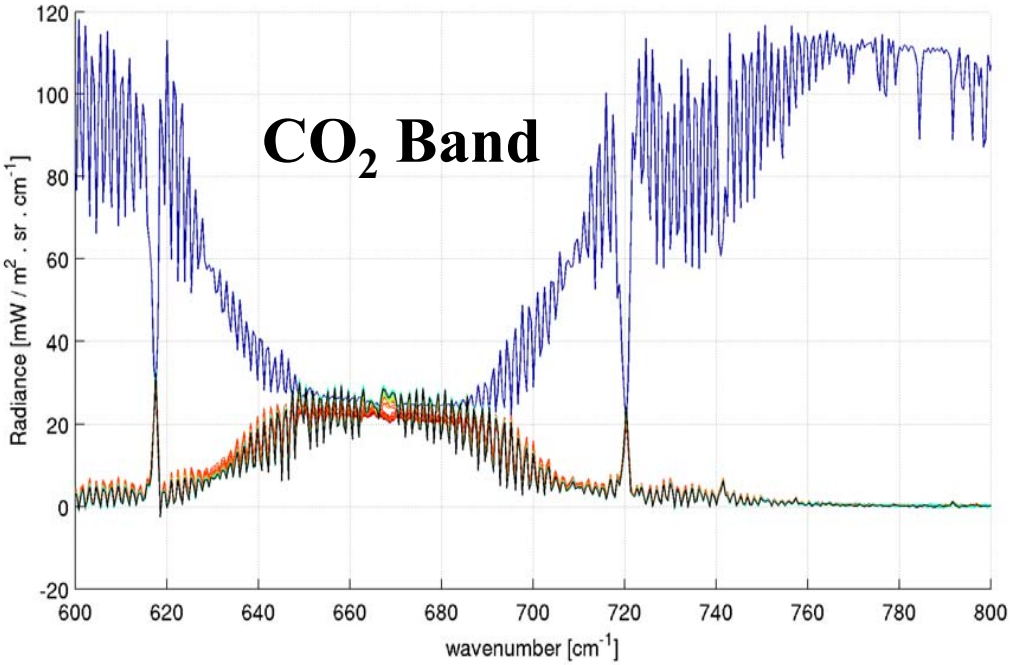


Scanning HIS Relative Humidity Retrieval
from TES Flight on 17 January 2006

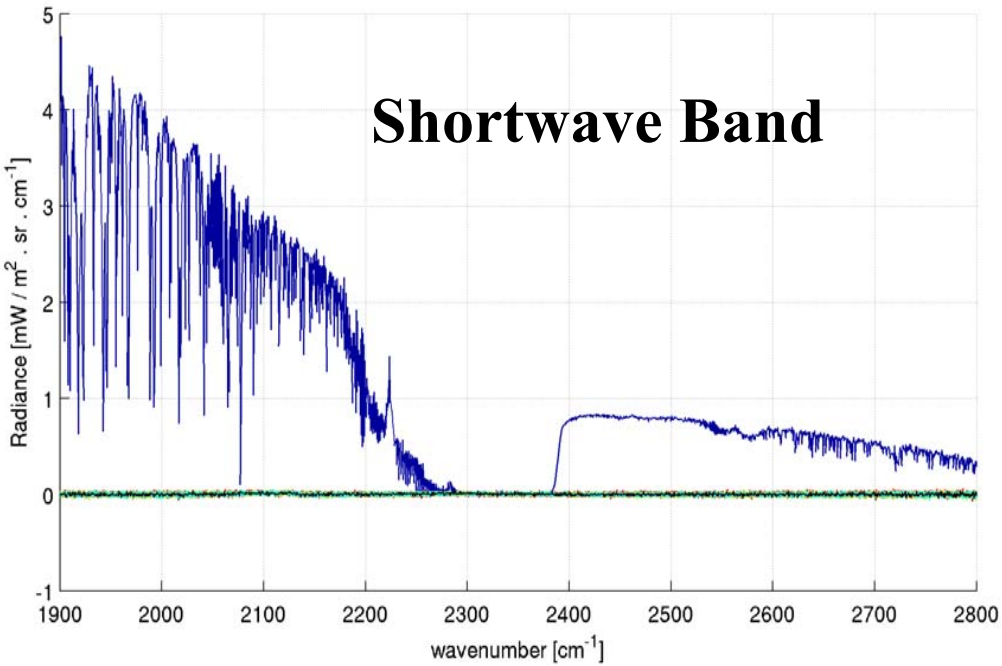


5. Thin Cirrus

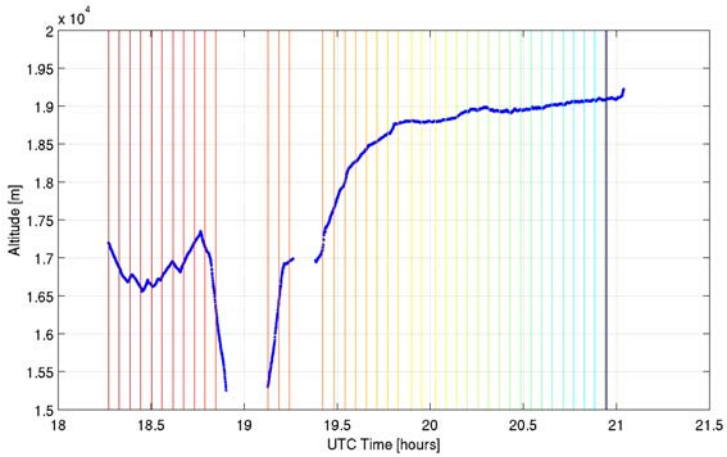
Simple Up-looking analysis



S-HIS
Up-looking & Down-looking
19 January
CRAVE

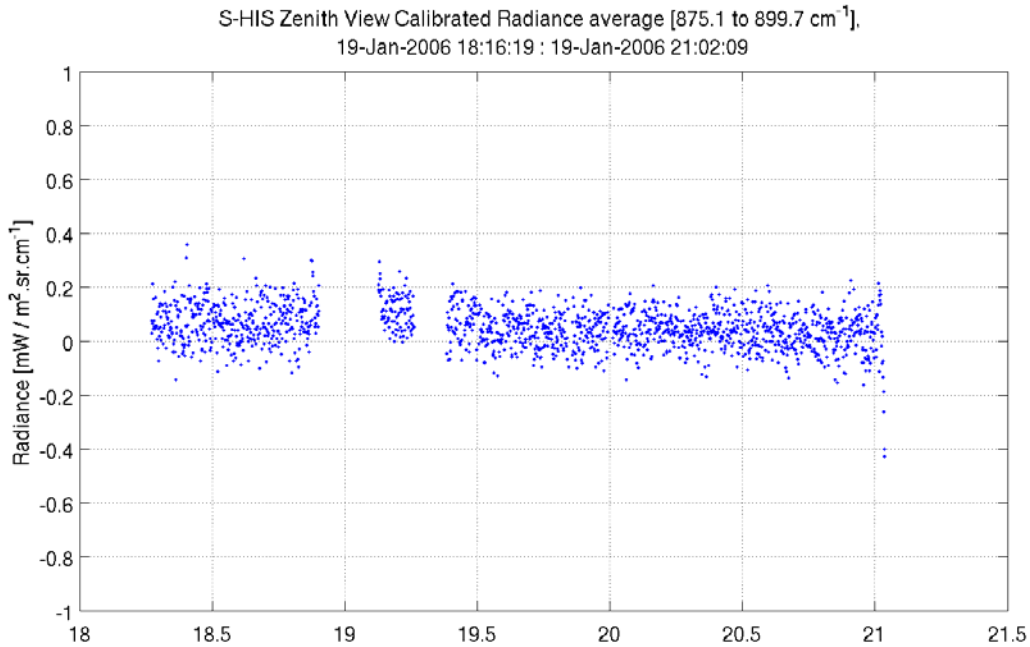


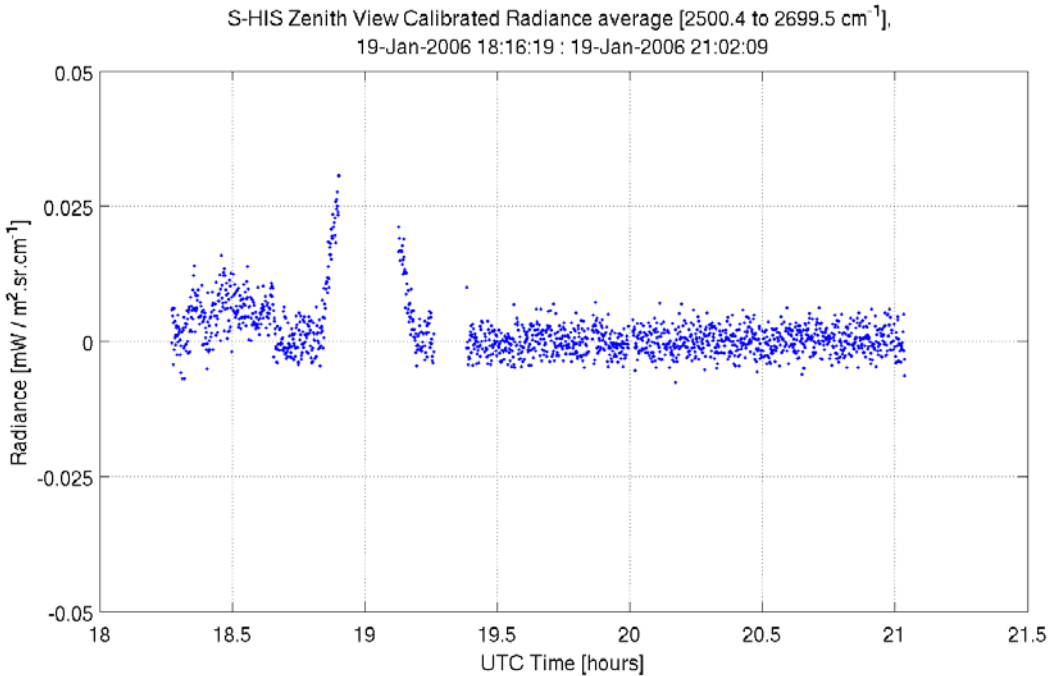
Altitude



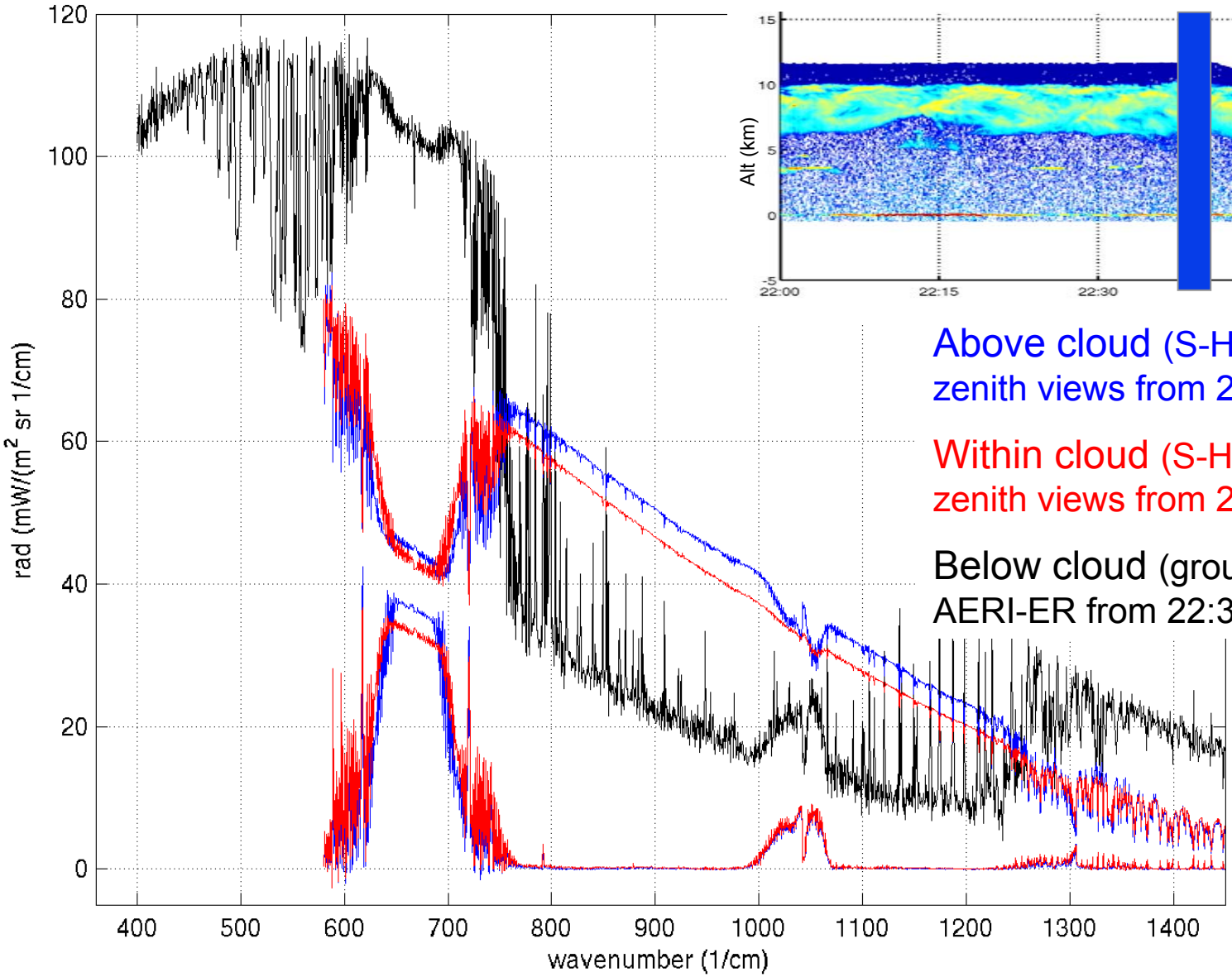
S-HIS Up-looking

Insensitive to very thin Cirrus — Detailed analysis of Down-looking required for characterization





MPACE 10/17: Sample SHIS and AERI-ER spectra for radiative transfer studies



Above cloud (S-HIS nadir and zenith views from 22:35 to 22:40)

Within cloud (S-HIS nadir and zenith views from 22:55 to 23:00)

Below cloud (ground based AERI-ER from 22:35 to 23:00)